MASTER OF SCIENCE
IN
ELECTRICAL ENGINEERING

IDENTIFICATION OF PUSH-TO-TALK TRANSMITTERS USING WAVELETS AND SPECTRAL CORRELATION

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The purpose of this thesis is to find an automated way to identify push-to-talk transmitters using a wavelet or a spectral correlation based approach. In the Wavelet approach, a distance algorithm is applied to the wavelet scales of the signal and the template. One signal from each transmitter– signal set is taken as a template. The distance algorithm computes the distance between the local extrema of the wavelet coefficients of the template and the signal. Results show that the Wavelet Transform (WT) distance algorithm is able to classify the four signal sets accurately. Good identification results are achieved even at low signal-to-noise ratios. In the spectral correlation approach an averaged template for each signal set is used. The spectral coefficients for templates and signals are computed by extracting the magnitude squared of the Fast Fourier Transform (FFT) of the data. This method performs better for most signals than the wavelet method because it can identify at lower signal to noise levels than the wavelet method does.

IN-SITU MEASUREMENT OF TOTAL DOSE RADIATION EFFECTS ON PARALLEL PLATE MOS CAPACITORS USING THE NPS LINEAR ACCELERATOR

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The study of radiation effects to electronics circuits has been ongoing almost as long as there have been satellites and spacecraft in space. The response to radiation over the planned life of the space system is of great concern to system designers. Operational amplifiers are one of the most basic elements in all electronic systems. This research examines radiation effects of part of a Metal Oxide Semiconductor (MOS) operational amplifier and is applicable to Complimentary MOS (CMOS) technology as well. More specifically, it is pertinent to MOS capacitors used to internally compensate op amps. First a review of semiconductor theory is presented followed by a discussion of damage mechanisms to MOS capacitors and a brief look at operational amplifier fundamentals. MOS capacitors, constructed by previous research efforts using the MOSIS technique, were selected as the internally compensating elements for simple low pass filters. Using the Naval Postgraduate School linear accelerator, these capacitors were irradiated with pulsed electrons possessing energies of up to 26 MeV for varying times. In-situ measurements were taken to immediately determine the capacitance value via the measured filter break frequency as a function of fluence. Separate irradiation runs were performed on three MOSIS capacitors and were terminated upon filter failure. This research concludes with a hypothesis of the filter failure mechanism and suggested areas for expansion of continuing research efforts. This is believed to be the first time such an experiment has been performed.

LINE AND CIRCLE FORMATION OF DISTRIBUTED AUTONOMOUS MOBILE ROBOTS WITH LIMITED SENSOR RANGE
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In the literature, formation problems for idealized distributed autonomous mobile robots were studied. Idealized robots are represented by a dimensionless point, are able to instantaneously move in any direction and are equipped with perfect range sensors. In this thesis, line and circle formation problems of distributed mobile robots that are subjected to physical constraints are addressed. It is assumed that mobile robots that are subjected to physical constraints are addressed. It is assumed that mobile robots have physical dimensions, and their motions are governed by physical laws. They are equipped with sonar and infrared sensors in which sensor ranges are limited. A new line algorithm based on least-square line fitting, a new circle algorithm, and a merge algorithm are presented. All the algorithms are developed with consideration of physical robots and realistic sensors, and are validated through extensive simulations. Formation problems for mobile robots with limited visibility are also studied. In this case, robots are assumed to be randomly distributed in a large rectangular field such that one robot may not see other robots. An algorithm is developed that makes each robot converge to the center of the field before executing a line or circle algorithm.

GEOMETRIC FORMATION WITH UNIFORM DISTRIBUTION AND MOVEMENT IN FORMATION OF DISTRIBUTED MOBILE ROBOTS
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The formation problem of distributed mobile robots was studied in the literature for idealized robots. Idealized robots are able to instantaneously move in any direction, and are equipped with perfect range sensors. In this study, the formation problem of distributed mobile robots that are subject to physical constraints is addressed. Mobile robots considered in this study have physical dimensions and their motions are governed by physical laws. They are equipped with sonar and infrared range sensors. The formation of lines and circles by using the potential field method is investigated in detail. It is demonstrated that line and circle algorithms developed for idealized robots do not work well for physical robots. New line and circle algorithms, with consideration of physical robots and sensors, are presented and validated through extensive simulations. Movement in formation of a small group of physical mobile robots is also studied. An algorithm is developed using the potential field method that makes robots move through a work space filled with many obstacles while maintaining the formation.

DEVELOPMENT OF A NEW PREDICTION ALGORITHM AND A SIMULATOR FOR THE PREDICTIVE READ CACHE (PRC)
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Efforts to bridge the cycle-time gap between high-end microprocessors and low-speed main memories have led to a hierarchical approach in memory subsystem design. The predictive read cache (PRC) has been developed as an alternative way to overcome the speed discrepancy without incurring the hardware cost of a second-level cache. Although

the PRC can provide an improvement over a memory hierarchy using only a first-level cache, previous studies have shown that its performance is degraded due to the poor locality of reference caused by program branches, subroutine calls, and context switches.

This thesis develops a new prediction algorithm that allows the PRC to track the miss patterns of the first-level cache, even with programs exhibiting poor locality. It presents PRC design alternatives and hardware cost estimates for the implementation of the new algorithm. The architectural support needed from the underlying microprocessor is also discussed.

The second part of the thesis involves the development of a memory hierarchy simulator and an address-trace conversion program to perform trace-driven simulations of the PRC. Using address traces captured from a SPARC-based computer system, the simulations show that the new prediction algorithm provides a significant improvement in the PRC performance. This makes the PRC ideal for embedded systems in space-based, weapons-based and portable/mobile computing applications.

DESIGN OF A UNIVERSAL TEST PLATFORM FOR RADIATION TESTING OF DIGITAL COMPONENTS
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In this research, programmable, microcontroller-based test hardware was designed, constructed, debugged, and programmed. The wire-wrapped board will be used to test two custom static random access memory (SRAM) chips, as well as other custom chips designed at the Naval Postgraduate School. Components for the test hardware were selected to allow prototyping with standard parts that can later be replaced with radiation hardened parts as budgets permit. Control of the test hardware is via a RS-232 serial interface, which allows remote control programming and monitoring of the test hardware and device being tested.

GALLIUM ARSENIDE DRAM MEMORY CELL DESIGN AND EVALUATION OF TEST METHODS
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This thesis proposes a new Gallium Arsenide (GaAs) Dynamic Random Access memory (DRAM) storage cell design based on an n-type, depletion mode diode and evaluates an Emitter Coupled Logic (ECL) based test platform. The depletion mode diode storage cell exhibits improved charge storage and maintenance characteristics when compared with a previously designed capacitor-based storage cell. Power requirements of the diode-based cell are marginally increased. The modularity of the new diode-based design produces impressive improvements in Very Large Scale Integration (VLSI) layout. The smaller design promises a higher degree of memory cell integration for future GaAs DRAM applications. The ECL test platform provides DATA, READ, WRITE, REFRESH and CLOCK signals as well as power and ground requirements for a GaAs DRAM chip in a 132-pin package. All testbench systems are tested and prove functional but CLOCK and REFRESH signal integrity suffer from noise and connector losses above 10 MHz. Ultimately, the design fails as a test platform for the existing GaAs DRAM due to pin-out incompatibility. Recommendations for future test platforms are discussed along with suggestions for incorporation of the diode-based memory cell in new DRAM designs.

POWER RECOVERY OF RADIATION DAMAGED MOCVD GROWN INDIUM PHOSPHIDE ON SILICON SOLAR CELLS THROUGH ARGON-ION LASER ANNEALING

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This thesis reports the results of a laser annealing technique used to remove defect sites from radiation damaged indium phosphide on silicon MOCVD grown solar cells. This involves the illumination of damaged solar cells with a continuous wave laser to produce a large forward-biased current. The InP/Si cells were irradiated with 1 MeV electrons to a given fluence, and tested for degradation. Light from an argon laser was used to illuminate four cells with an irradiance of 2.5 W/cm^2, producing a current density 3 to 5 times larger than AM0 conditions. Cells were annealed at 19½C with the laser and at 25½C under AM0 conditions. Annealing under laser illumination of n/p-type cells resulted in recovery of 48%. P/n type cells lost 4 to 12% of the assumed degradation. Annealing under AM0 conditions resulted in power recovery of 70% in n/p type cells. P/n-type cells recovered approximately 16% of lost power recovery of 70% in n/p type cells. P/n-type cells recovered approximately 16% of lost power. Results indicate that significant power recovery results from the annealing of defects within n/p type InP/Si solar cells.

REAL-TIME SONAR CLASSIFICATION FOR AUTONOMOUS UNDERWATER VEHICLES

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The Naval Postgraduate School autonomous underwater vehicle (AUV) Phoenix did not have any sonar classification capabilities and only a basic collision avoidance system. The Phoenix also did not have the capability of dynamically representing its environment for path planning purposes.

This thesis creates a sonar module that handles real-time object classification and enables collision avoidance at the Tactical level. The sonar module developed communicates directly with the available sonar and preprocesses raw data to a range/bearing data pair. The module then processes the range/bearing data using parametric regression to form line segments. A polyhedron-building algorithm combines line segments to form objects and classifies them based on their attributes. When the Phoenix is transiting, the classifying algorithm detects collision threats and initiates collision avoidance procedures.

The result of this thesis is a fully implemented sonar module on the Phoenix. This module was tested in a virtual world, test tank and in the first ever sea-water testing of the Phoenix. The sonar module has demonstrated real-time sonar classification, run-time collision avoidance and the ability to dynamically update the representation of the unknown environment. The sonar module is a forked process written in the “C” language, functioning at the Tactical level. Source code and output from an actual Phoenix mission displaying the object classification of the sonar module are included.

PERFORMANCE ANALYSIS OF FFH/BPSK RECEIVERS WITH CONVOLUTIONAL CODING AND SOFT DECISION VITERBI DECODING OVER CHANNELS WITH PARTIAL-BAND NOISE INTERFERENCE

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An analysis of the performance of a binary phase shift keying (BPSK) communication system employing fast frequency-hopped (FFH) spread spectrum modulation, under conditions of hostile partial-band noise interference, is performed in this thesis. The data are assumed to be encoded using convolutional coding and the receivers are assumed to use soft decision Viterbi decoding.

The receiver structures to be examined are the conventional FFH/BPSK receiver with diversity, the conventional FFH/BPSK receiver with diversity and the assumption of perfect side information, and the noise-normalized FFH/BPSK combining receiver with diversity. The FFH/BPSK noise-normalized receiver with diversity minimizes the effects of hostile partial-band noise interference and alleviates the effects of fading. The effect of inaccurate measurement of the noise power present in each hop is also examined, and it is found that noise measurement error does not significantly degrade receiver performance. For the conventional FFH/BPSK receiver with perfect side information, the effect of a Ricean fading channel is also examined.

A COMPARISON STUDY OF CDMA VERSUS TDMA/FDMA LEO SATELLITE SYSTEMS

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In this thesis, two LEO satellite systems with different multiple access schemes are analyzed. The first system, GLOBALSTAR, uses CDMA. Equations are developed to calculate the maximum capacity of one satellite, of one satellite's user beam, and of the entire GLOBALSTAR system over CONUS. A detailed description of GLOBALSTAR's outrage probability, the probability that a call will be dropped from the system or blocked from connection with the system, is given and graphed against varying average call time and varying call arrival rate. The second system, IRIDIUM, uses TDMA/FDMA. Equations are similarly developed to calculate the maximum capacity of one satellite, of one satellite's user beam, and of the entire IRIDIUM system over CONUS. The probability of success or failure of an IRIDIUM subscriber obtaining a system channel is given by the Erlang Loss Formula and graphed against varying average call time and varying call arrival rate. Results show GLOBALSTAR provides five times the service capacity of IRIDIUM over CONUS and provides a better probability of obtaining a system channel for a call than will IRIDIUM.

OPTIMAL DIGITAL DETECTION OF ACOUSTIC SIGNALS IN COLORED NOISE

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This thesis addresses optimal methods for the detection of acoustic signals corrupted by colored noise. In achieving this we provide a study of the characteristics of ambient noise in the ocean and the digital techniques which can be used in the process of detecting known acoustic signals which are corrupted by that noise. Various techniques are studied, in particular the use of matrix decomposition techniques applied to the correlation matrix or to a data matrix, and the

matched filter for colored noise. Other methods such as the inverse filter, the differential operator, and the adaptive prediction-error filter will also be looked at for their whitening properties. The theoretical foundations of those techniques are presented as well as the application of each method to the problem. Simulations are conducted for each technique in order to provide quantified performance measurements supporting the use of each method.

ANALYSIS AND PERFORMANCE COMPARISON OF ADAPTIVE DIFFERENTIAL PULSE CODE MODULATION DATA COMPRESSION SYSTEMS
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Advances in audio data compression are largely driven by the need to conserve transmission rate or bandwidth, while maintaining the ability to accurately reconstruct the signal at the receiver. This thesis examines data compression methods with an emphasis on techniques for the compression of audio data. An overview of data compression schemes is presented to provide the background for a performance comparison between selected versions of data compression systems featuring adaptive differential pulse code modulation (ADPCM) schemes. Two different types of data compression systems are investigated; IIR and FIR impulse implementations. A modification to the basic ADPCM system using a modular function is implemented. The modular operation results in a smaller size codebook and prevents data expansion when the source is not matched to the code. This modification is utilized for both types of ADPCM coders compared. To complete the compression system, Huffman coding is employed to encode and decode the compressed data to and from binary form.

DETECTION AND IDENTIFICATION OF CYCLOSTATIONARY SIGNALS
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Propeller noise can be modeled as an amplitude modulated (AM) signal. Cyclic Spectral Analysis has been used successfully to detect the presence of analog and digitally modulated signals in communication systems. It can also identify the type of modulation. Programs for Signal Processing based on compiled languages such as FORTRAN or C are not user friendly, and MATLAB based programs have become the *de facto* language and tools for signal processing engineers worldwide.

This thesis describes the implementation in MATLAB of two fast methods of computing the Spectral Correlation Density (SCD) Function estimate, the FFT Accumulation Method (FAM) and the Strip Spectral Correlation Algorithm (SSCA), to perform Cyclic Analysis. Both methods are based on the Fast Fourier Transform (FFT) algorithm. The results are presented and areas of possible enhancement for propeller noise detection and identification are discussed.

FORMAL SPECIFICATION, VERIFICATION, AND ANALYSIS OF THE RELIABLE MULTICAST TRANSPORT PROTOCOL

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This thesis explores the feasibility and reliability of a Reliable Multicast Transport Protocol (RMTP) under development at AT&T Bell Laboratories. A formal specification and verification was conducted using the *systems of communicating machines* model to determine if the specification of the protocol is free from deadlocks, livelocks, and unspecified receptions. This model was programmed using the ADA programming language. An analysis was done using these programs as input to programs that perform reachability analysis on the model of the protocol. Results of the analysis indicate that the RMTP protocol is free from deadlocks and livelocks with a few exceptions. Suggestions are provided to improve the specification of the protocol. In addition to the research on the RMTP protocol, greater knowledge was acquired in the area of modeling communication channels and networks.

DESIGN TRADEOFFS IN RADIATION HARDENED ASICS FOR SPACE APPLICATIONS

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Third Reader: Steven S. Chang, Department of Defense

The availability of radiation hardened integrated circuits (ICs) is declining, yet the need for radiation hardened ICs is growing. This thesis explores techniques for radiation hardening ICs fabricated with commercial CMOS processes rather than using more expensive process hardening methods. A design environment based on the Boeing Defense and Space Group Aerospace Compiler is investigated for speed, accuracy, ease of use, and level of radiation hardness. A design and implementation of the Fireworks2 FIR filter is utilized to evaluate the area, speed, power consumption and radiation hardness trade-offs of using the described design environment.

IMPLEMENTATION OF A DIGITAL COMMUNICATION SYSTEM USING QPSK MODULATION

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With the advances in high speed, programmable digital signal processing (DSP) chips, modern communications links are using a combination of DSP techniques and digital communications methods to realize faster, reconfigurable, and modular systems. This thesis details the software implementation of a modern digital communication system combining various DSP functions, channel Forward Error Correcting (FEC) algorithms, and digital modulation methods. The digital modulation schemes considered here include both baseband and Quadrature Phase Shift Keying (QPSK) techniques. The proposed communication system will serve as a practical tool useful for simulating the transmission of any digital data. The various modules of the system include source encoders/decoders, data compression functions, channel encoders/decoders, and modulators/demodulators. Implementation consists of coding the various link functions in C and integrating them as a complete system. The results show the viability of a QPSK modulated digital communications link and point the direction of future research towards software radio.

MULTILEVEL DATA ASSOCIATION FOR THE VESSEL TRAFFIC SERVICES SYSTEM AND THE JOINT MARITIME COMMAND INFORMATION SYSTEM

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This thesis develops an algorithm to fuse redundant observations due to multiple sensor coverage of a vessel. Fuzzy membership functions are used as a measure of correlation, and a fuzzy associative system determines which observations represent the same vessel. The result is a computationally efficient algorithm. The output of the system is a unique set of vessels identified by unique platform identifiers. Results of tests based on computer simulation of overlapping radar coverage show that the fusion algorithm correctly correlates and fuses the sensor observations. That the VTS system is a subset of the Joint Maritime Command Information System (JMCIS) and ultimately the Global Command and Control Software (GCCS) system makes this algorithm pertinent not only to the U.S. Coast Guard, but also to the Navy, DoD and other agencies such as the Canadian Navy that use this software.

DESIGN AND EVALUATION OF MINE AND UXO DETECTORS TO AUTONOMOUS MOBILE ROBOTS

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The study focuses on the development of a light weight detector to be used for the purpose of mine / Unexploded Ordnance (UXO) detection. The detector was developed based upon a twin oscillator design, and the performance of this design was tested with respect to diameter of the sensing coil, operating frequency, and the number of turns of the sensing coil. The results of this study provide a field tunable, light weight, low power mine / UXO detector with significant range. The ability to equip a robot with this device and send it into the field will prove to be an invaluable asset to ongoing mine sweeping operations.

DEVELOPMENT AND VALIDATION OF A SECOND GENERATION VISIBILITY-BASED MODEL FOR PREDICTING SUBJECTIVE AND OBJECTIVE MINIMUM RESOLVABLE TEMPERATURE DIFFERENCE PERFORMANCE FOR STARING THERMAL IMAGING SYSTEMS

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Several models have been proposed to predict the minimum resolvable temperature difference (MRTD) performance of second generation thermal imaging systems (TIS) which incorporate staring focal plane arrays. It has been suggested that these models are not accurate for predicting the performance of second generation staring focal plane arrays which have severe phasing or sampling characteristics not amenable to linear modulation transfer function analysis. A second problem with these models is that they require a particular set of assumptions concerning the observer eye/brain recognition process, which limits their usefulness in the prediction of the performance for systems that incorporate automatic target recognition (ATR) devices. In this thesis, a new model is presented for predicting the MRTD performance of second generation thermal imagers based on a minimum threshold input contrast, and a contrast reduction

factor due to aliasing and blurring effects. The model makes no assumptions regarding the recognition process, which allows a separate threshold value to be defined for either a human or machine observer. The model incorporates aliasing concepts, and extends performance prediction beyond the nominal Nyquist rate of the system. The model's predictions are compared to the predictions of the current standard FLIR92 model and measured laboratory results for two different staring focal plane array imagers. In both cases, the model's predictions match measured results more closely than the predictions of FLIR92.

COMMUNICATION CRITICAL PATH FOR GPS-ASSISTED TDOA GEOLOCATION SYSTEM

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A large number of network management techniques exist for planning and scheduling large and complex projects. One such technique, the Activity-on-Node Network, is applied to a prototype system developed by the Applied Research Lab at the University of Texas. This prototype system uses time-difference-of-arrival techniques and the Global Positioning System (GPS) within a time-of-arrival algorithm for computing the geolocation of a target transmitter. A critical path is determined for a single transmitter geolocation. This paper defines the content and format for each required message among the network users, and investigates the impact of available communication bandwidth on geolocation fix rate.

OPTIMAL LINEAR QUADRATIC GAUSSIAN CONTROLLER DESIGN FOR A FLEXIBLE-SPACECRAFT SIMULATOR

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The experimental verification of active control methods for vibration suppression of large flexible structures in space is essential for precision optical and military payload operations. The Flexible-Spacecraft Simulator (FSS) at the Naval Postgraduate School is designed for testing such control designs. The experimental setup simulates the pitch axis motion of a rigid body spacecraft with a flexible antenna support structure connected to a rigid reflector. A twenty-four state finite element analytical model is used to characterize the flexible appendage. Piezoelectric sensors and actuators are used for feedback control for fibration suppression. In addition, an external infrared camera provides direct feedback of the flexible structure's elbow and tip displacements and rotations. A Multiple-Input-Multiple-Output (MIMO) linear quadratic gaussian (LQG) controller is designed using linear quadratic regulator (LQR) optimal control theory and an optimal Kalman estimator as the state observer to meet desired performance specifications. The objective is to minimize the motion of the reflector.

ANALYSIS AND DESIGN OF CMOS VOLTAGE-FOLDING CIRCUITS AND THEIR USE IN HIGH SPEED ADCS

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This thesis provides a complete numerical analysis of a complementary metal-oxide semiconductor (CMOS) analog folding circuit architecture, which is comprised of a number of parallel folding stages connected to an output stage. The bias point (reference voltage at which input signal is to be folded) and differential input responses are determined analytically. Current source requirements are also determined to ensure that the transistors remain in saturation. Using the analysis, a design process for implementing the folding circuit as a preprocessor for an analog-to-digital converter (ADC) is developed. A folding circuit preprocessor for a 6-bit optimum symmetrical number system (SNS) ADC is designed using this process. The designed circuit output is numerically analyzed and compared with HSPICE simulation results to verify the design process. Transfer function results are evaluated numerically to examine the preprocessor performance. Decimation bands are utilized within the ADC to eliminate coding errors. The effects of fabrication process tolerances, which alter the metal-oxide semiconductor field-effect transistor (MOSFET) parameters used in the analysis and design of the circuit, are quantified using a four-corner approach.

A COMPARISON BETWEEN POWER LINE NOISE LEVEL FIELD MEASUREMENTS AND MAN-MADE RADIO NOISE PREDICTION CURVES IN THE HIGH FREQUENCY RADIO BAND

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Radio frequency noise is often the limiting factor in the ability of a communications receiver to discern a desired signal from man-made interference. The predominate man-made radio noise source in the high frequency radio band is gap type breakdown discharges on electric power distribution lines. The International Radio Consultative Committee (CCIR) has published its Report 258 which predicts the level of man-made radio noise in the business, residential, rural, and quiet rural environmental categories.

This thesis compares field measurements of gap type breakdown discharge generated noise, made in the high and very high frequency radio bands, to CCIR Report 258 predictions. It is shown that CCIR noise-level predictions correspond to field measurements in the low end of the high frequency band. At higher frequencies the CCIR curve consistently predicts a lower noise-level than was measured in the field. An explanation for the difference between field measurements and CCIR predictions is presented.

A trend noticed in the noise-amplitude versus receiver bandwidth data measurements is investigated and leads to the development of a receiver bandwidth adjustment matrix. Using this matrix the noise-power measurements made in one receiver bandwidth can be scaled to a different bandwidth.

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

SPEED, POWER CONSUMPTION, AND IMPEDANCE IN GALLIUM ARSENIDE IC INTERCONNECTION CIRCUITS

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The goal of this project is to determine the feasibility of conserving power while maintaining reasonably high speed in Gallium Arsenide integrated circuit interconnection circuits by increasing the characteristic impedance of microstrip or stripline printed circuit board. This thesis presents the modeling and simulation of output driver and input receiver circuits for Gallium Arsenide digital ICs. Impedance controlled printed circuit board transmission lines are also studied. MATLAB is used to model and calculate the impedance that can be obtained using a microstrip and/or stripline printed circuit board interconnect. This information is then used with HSPICE to model and simulate transmission line interconnects. HSPICE is also used to model and simulate the design of the output driver and input receiver circuits for use with the printed circuit board. Finally, the IC is laid out using MAGIC to show differences in circuit size at different impedances.

RADIATED POWER CONTROL FOR NARROW-BAND DIGITAL LINKS

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Radiated power control is one way to increase the capacity of a narrow-band channel with channel reuse. But channel reuse introduces the problem of a co-channel interference. Use of a power control algorithm not only can optimize the radiated power for a particular quality of service (QOS) but also minimize co-channel interference at the receiver.

In this thesis, we present the experimental results that relate the dependency of the logarithm of bit error rate (BER) versus the logarithm of the ratio of the energy per bit to the one-sided noise power spectral density (E_b/N). The dependency of BER to E_b/N_0 in an ideal and to E_b/N in a nonideal thermal noise limited receiver were analyzed. One important step in the analysis is the procedure of curve fitting used to characterize the radiated power for a particular system. In addition, we perform the experiments of BER measurement with a fixed power at a fixed location and the experiment to obtain the relationship between BER and the transmission distance with fixed radiated power. A curve fitting procedure to find the selected system parameter ρ is based on the results of BER measurement at fixed distance with variable power. The fixed step power control algorithm is also presented here. Experimental results are shown and compared to results expected from theory.

TIME-DIFFERENCE-OF-ARRIVAL ESTIMATION USING CYCLOSTATIONARY SIGNAL PROCESSING TECHNIQUES (PART I/PART II)

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Advisors: Herschel Loomis, Jr., Department of Electrical and Computer Engineering
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Time-Difference-of-Arrival (TDOA) estimation is the estimation of the relative time difference observed in the reception of a signal that impinges on two spatially separated receivers. Conventional approaches to estimating TDOA values have primarily consisted of exploiting the properties inherent in the simple cross-correlation function which ideally exhibits a peak at the TDOA value. Though conventional methods produce very sound results in many instances, they suffer from important intrinsic shortcomings. Co-channel interference and strong noise can adversely affect these methods resulting in estimate ambiguities and inaccuracies. Development of the Spectral Coherence Align-

ment (SPECCOA), Generalized Spectral Coherence Alignment (GSPECCOA), and Maximum Likelihood (ML) algorithms has provided a means to overcome these deficiencies through exploitation of the cyclostationary nature of signals. These signal processing algorithms possess a signal-selectivity property that renders them inherently more tolerant to noise and interference. This thesis contains a performance comparison of conventional and cyclostationary-based techniques demonstrating the efficacy of this highly desirable property under controlled, simulated environments and on real-world collected data and presents an assessment of the potential for future applications.

WIDEBAND SIGNAL ANALYSIS AND SYNTHESIS APPLIED TO ELECTROMAGNETIC TRANSIENT WAVEFORMS
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B.S., Korea Military Academy, 1990
Master of Science in Electrical Engineering-March 1996
Advisor: Murali Tummala, Department of Electrical and Computer Engineering

This thesis presents the bandpass inverse fast-Fourier transform (IFFT) filter bank and the multirate digital filter bank techniques to synthesize test point waveforms from constituent waveforms recorded by two instruments as part of an aircraft electromagnetic hardness evaluation test. The component waveforms are recorded by two separate measurement systems (High-Powered Pulse Waveform (HPW) in the time domain and Continuous Sweep Waveform (CSW) in the frequency domain) under two different aircraft orientations (parallel and perpendicular). Data from two orientations are combined using the sinusoidal modeling algorithm (SMA). The tree-structured filter bank with power symmetric overlap method and the bandpass IFFT with spectral concatenation method are developed to further combine these waveforms with an overlapping frequency spectrum to produce the corresponding synthesized test point waveform.

AUTOMATIC SYNTHETIC SONAR TRANSIENT GENERATION
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B.S.C.S., United States Naval Academy, 1988
Master of Science in Electrical Engineering-December 1995
Advisor: Charles W. Therrien, Department of Electrical and Computer Engineering

This thesis addresses the problem of extending and available data base of sonar transients by analysis/synthesis methods. Two specific methods are considered and automated for this purpose: a stochastic method and a stochastic/deterministic method. The stochastic method employes a time varying Burg algorithm to model the original signals, then stores the essential parameters in a database. Once all of the original signals are in this database, the segments of the original signals are mixed in a natural format to produce a synthetic signal unlike any original signal yet possessing the aural, spectral, and temporal characteristics of the class. The stochastic/deterministic method uses an ARMA model to extract the most significant time varying harmonics from the original signal then employs the same time varying Burg algorithm to model the remainder of the signal. The parameters are stored and used to create synthetic signals in the same manner as the stochastic method. Results of the two methods are compared.

AR PARAMETER ESTIMATION USING TMS320C30 DIGITAL SIGNAL PROCESSOR CHIP
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B.S., Turkish Naval Academy, 1989
Master of Science in Electrical Engineering-December 1995
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Autoregressive analysis is used in modern signal processing applications for modeling and estimation of random signals. High speed digital signal processors with advanced architecture and special digital signal processing instructions,

mostly compiled in C language, can be used in these applications to achieve realtime performance. A commercially available digital signal processor has been used in this work to estimate the AR parameters and power spectral density from the given input data by using the Levinson, Burg and Schur algorithms. This work produced a library file that contains the object files of the AR parameter estimation algorithms. The time required in terms of the cycle counts to execute each algorithm is listed for different data lengths and model orders.

THE MODIFICATION OF A SURFACE SHIPBORN RADAR (DECCA 1226) IN ORDER TO MEET MILITARY STANDARDS (HIGH RESOLUTION) WITHOUT CHANGING ITS ELECTRONIC SIGNATURE

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Advisor: Fred Levien, Department of Electrical and Computer Engineering
Second Reader: Charles W. Therrien, Department of Electrical and Computer Engineering

This is a theoretical study examining the possibility to use a commercial, shipborne navigational radar, for target classification and identification, without changing its electronic signature. The reason for such a modification is that using sophisticated pulse forms for target recognition can betray the user's presence and give an intelligence advantage to potential enemy platforms.

In order to extract a target's class or identity, the data of the radar's video detector are fed to a high performance PC with digitizing capability. There the target's class is obtained through a series of transforms, while the target's identity is obtained by computing the target's frequency response to a very short pulse using the MUSIC method. While the classification process does not require any changes in the transmitter, in order to obtain target identification in tactically useful ranges it is necessary to increase the transmitter's power and add an additional very short pulse.

TACTICAL NAVAL APPLICATIONS OF THE "IMPROVED MANY-ON-MANY" RADAR SIMULATION PROGRAM

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Master of Science in Electrical Engineering-September 1996
Advisor: Frederic H. Levien, Department of Electrical and Computer Engineering
Second Reader: Phillip E. Pace, Department of Electrical and Computer Engineering

The "Improved Many-on-Many" (IMOM) radar simulation modeling program was developed and is used by the United States Air Force for mission planning of its tactical aircraft. Although the U. S. Navy has a similar software product designed for its tactical aircraft, it currently does not use any radar simulation modeling program specifically designed to strategically position its surface fleet of frigates, destroyers, cruisers, carriers, and amphibious ships. The U. S. Navy's new focus on operations in the littoral environment requires surface ships to operate in regions that present greater challenges to a carrier or amphibious battlegroup. Surface ship commanders need radar simulation tools to allow them to quickly and accurately model enemy radar installations, expected radar ranges, and weapons envelopes.

The purpose of this thesis is to evaluate the potential adaptability of IMOM in a surface navy planning role. Particular attention is paid to how the littoral environment affects surface radar.

LINEAR MODELING OF TILTROTOR AIRCRAFT (IN HELICOPTER AND AIRPLANE MODES) FOR STABILITY ANALYSIS AND PRELIMINARY DESIGN

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Master of Science in Electrical Engineering-June 1996
Master of Science in Aeronautical Engineering-June 1996
Advisors: Robert G. Hutchins, Department of Electrical and Computer Engineering
E. Roberts Wood, Department of Aeronautics and Astronautics

This thesis investigates the linear state space modeling of a tiltrotor aircraft by modifying an existing MATLAB routine which is used for preliminary (helicopter) stability and control analysis. The modifications consist of changing existing script files along with adding new ones. The modifications result in having a routine that allows the input of tiltrotor characteristics and subsequently generates a state space model along with other stability and control characteristics. The tiltrotor modeling is validated by the input of XV-15 characteristic data into the program and performing a eigenvalue comparison with a model of a similar tiltrotor, the V-22. A more extensive comparison is performed with another XV-15 model which has been extensively used and validated with wind tunnel and flight.

BROADBAND HF AND VHF ANTENNA DESIGN WITH TERRAIN MODELING

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Richard W. Adler, Department of Electrical and Computer Engineering

The objective of this thesis was the design and analysis of broadband antennas to be used with sounders for trans-equatorial propagation research. Sites have been identified in Oahu and Rarotonga. A four step process is used in the design of the antennas. The four steps are: theoretical design, preliminary analysis with ELNEC software, detailed analysis with NEC-4 software and finally terrain modeling with PAINT, MN and TA software.

Preliminary work led to the decision to use two antennas at each site. On Oahu a HF log-periodic antenna is used for the 2-25 MHz band and a VHF log-periodic antenna is used for the 25-60 MHz band. On Rarotonga a VHF log-periodic antenna is also used for the 25-60 MHz band, however a sloping V antenna is used for the 2-25 MHz band. Computer generated impedance values and radiation patterns are presented.

USE OF THE SYMMETRICAL NUMBER SYSTEM IN RESOLVING UNDERSAMPLING ALIASES

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Second Reader: David Styer, Department of Mathematical Sciences, University of Cincinnati

Two algorithms are presented which allow for the unambiguous resolution of multiple undersampled frequency components in a signal. Digital signal processing is usually governed by the Nyquist criterion which limits the amount of information that can be unambiguously stored and recovered digitally to a spectral width no larger than half the sampling frequency. Both algorithms resolve a spectrum beyond Nyquist by using additional information. The first method samples a signal more than once using a different sampling frequency each time. The second method utilizes a single sampling frequency which is used to sample both the signal and a band-limited version of the signal. When using multiple sampling frequencies, each sampling frequency yields a digital sequence which, in turn, has a unique spectrum when the Discrete Fourier Transform (DFT) is applied. The bin and amplitude information from each of the resulting undersampled spectra is then recombined to resolve the original spectrum. In like manner, when using a

single sampling frequency the spectra of both the signal and its band-limited version are recombined to obtain the solution. Given a sampling frequency, both algorithms allow for the unambiguous resolution of a signal with a spectral width at least twice as large as that predicted by Nyquist.

VELOCITY COMPENSATION IN STEPPED FREQUENCY RADAR
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Master of Science in Electrical Engineering-December 1995
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As compared to the commonly used constant frequency radar waveforms, the stepped-frequency waveform can achieve high range resolution while still retaining the advantages of lower instantaneous receiver bandwidth and lower analog-to-digital sampling rate. However, the relative radial motion between the target and the stepped-frequency radar will result in performance degradations, such as range error, loss in signal-to-noise ratio, and degraded range resolution. The solution to this problem is to apply velocity compensation to the received signal, which can eliminate the degradations due to Doppler effects. Three velocity compensation schemes for the detection of a moving target in clutter are designed, discussed, and compared in this thesis. Also, a simulation is presented to verify the concepts, and simulation results are compared and discussed.

SPEECH COMPRESSION USING COSINE PACKET DECOMPOSITION
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Master of Science in Electrical Engineering-March 1996
Advisors: Monique P. Fargues, Department of Electrical and Computer Engineering
Ralph Hippenstiel, Department of Electrical and Computer Engineering

As digitization of data becomes more prevalent, the demands on existing communications networks and computer systems to cope with this increase become overwhelming. Currently, the speech compression problem is handled using the CELP (Code Excited Linear Prediction) scheme and its derivatives. Such techniques are the most frequently used for speech compression at medium-to-low ranges. Recent research conducted into the area of cosine packets has proven this field to be readily adaptable to speech compression and coding. In this thesis, speech compression schemes are developed using cosine-packet decomposition, minimum entropy basis selection, and an adaptive thresholding scheme for selecting coefficients. In addition, voiced-unvoiced segmentation and a denoising scheme are implemented. Test results show high compression ratios (1:50) with a good quality of reconstructed speech.

SIMULATION OF AN OPTICAL CORRELATOR CONFIGURED AS AN IMAGING SYSTEM USING LIQUID CRYSTAL TELEVISION SPATIAL LIGHT MODULATORS
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This thesis models the complex transmittance effects of liquid crystal television spatial light modulators (SLMs) in an optical correlator configured as an imaging system. The computer model implements both the ideal transmittance and the nonlinear measure transmittance which is a function of the voltage applied across the pixel of the liquid crystal device. The system modeled included the effects of a nonlinear input SLM input but assumed an ideal filter SLM. Input waveforms included both one-dimensional and two-dimensional spatial cosines and chirped cosines. Results show that the effects of the SLM transmittance nonlinearity can be minimized by limiting the input signal voltages to values falling on a piecewise linear region of the transmittance operating characteristics.

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

DESIGN OF A SATELLITE-BASED MICROELECTRONIC RADIATION TESTING EXPERIMENT

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Master of Science in Electrical Engineering-March 1996
Advisor: Douglas J. Fouts, Department of Electrical and Computer Engineering
Second Reader: Randy L. Borchardt, Department of Electrical and Computer Engineering

In this research, an electronic daughterboard to be used on the Microelectronics and Photonics Test Bed satellite was designed. A printed circuit board with radiation-hardened components was laid out to test various families of static RAM chips and an experimental Gallium-Arsenide integrated circuit. Computer-aided-design tools produced by Cadence Design Systems were used to logically and physically design the experiment. Output from the Cadence software provides the information necessary to fabricate, assemble, and test the board.

PLANARITY IN ROMDD'S OF MULTIPLE-VALUED SYMMETRIC FUNCTIONS

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An important consideration in the design of digital circuits is delay. A major source of delay in VLSI is interconnect. Crossings among interconnect require via's which cause resistance and additional delay. This thesis focuses on circuit design based on the reduced ordered multiple-valued decision diagram (ROMDD), a graph representation of a logic function. Crossings among edges in the ROMDD result in crossings in the circuit. Thus, ROMDD's without crossings reduce delay.

Since symmetric functions are important in the design of logic circuits, they are considered here. It is shown that a multiple-valued symmetric function has a planar ROMDD if and only if it is a pseudo-voting function. It is also shown that the number of such functions is $(r-1)\left(\begin{smallmatrix} n+r \\ n+1 \end{smallmatrix}\right)$ where r is the number of logic values and n is the number of variables.

It follows from this that the fraction of symmetric multiple-valued functions that have planar ROMDD's approaches 0 as n approaches infinity. Further, for planar ROMDD's of symmetric functions, it is shown that the worst case number of nodes is $n^2\left(1-\frac{1}{(r+1)}\right)$ and the average number of nodes is $n^2\left(1-\frac{1}{2r}\right)$ when n is large.

Additionally, multiple-valued *Fibonacci* functions are examined and conditions for planarity in their ROMDD representations are established.

IDENTIFICATION OF PUSH-TO-TALK TRANSMITTERS USING WAVELETS

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The main objective of this study is to find a wavelet-based, feature extracting algorithm for push-to-talk transmitter identification. A distance-measure algorithm is introduced to classify signals belonging to one of four transmitters. The signals are first preprocessed to put them into a form suitable for wavelet analysis. The preprocessing scheme includes taking envelopes and differentials. Median filtering is applied to the envelopes and the differentials to denoise the data. The preprocessed data takes on a pulse-like shape, which is suitable for wavelet processing. The distance algorithm is applied to the outputs (scales) of the wavelet transform. The distance algorithm uses local extrema of the wavelet

coefficients, and computes the distance between the local extrema of a template and the processed signals. A small distance implies high similarity. A signal from each transmitter is selected as a template. The distance measure is computed between any signal of interest and the reference templates. The signals are identified to belong to one of four transmitters according to the distance measure. A small distance measure indicates that the signal belongs to the transmitter from which the template originated. The distance algorithm can classify correctly the four different signal sets provided for the research and, even at lower signal-to-noise levels, good identification is achieved.

THE PROBABILITY OF DETECTION OF CERTAIN THREAT EMITTERS USING MULTIPLE COLLECTION SOURCES
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Master of Science in Electrical Engineering-June 1996
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Vicente C. Garcia, Department of Electrical and Computer Engineering

It has long been the practice of the military and national personnel to inform the warfighter when a threat emitter has been detected in their area of operations to ensure their safety. With the United States military being called upon by the President to take part in numerous Peace Keeping, Humanitarian Aid, Crisis Intervention and Military Operations, it is critical that military forces are given as much warning as possible that impending hostile acts might occur. It is therefore the purpose of this thesis to determine how well our various collection sources can detect threat emitters. In this thesis, the probability of detection of certain threat emitters using multiple collection sources is evaluated.

MULTIRESOLUTION IMAGE RECOGNITION USING THE WAVELET TRANSFORM
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Master of Science in Electrical Engineering-June 1996
Electrical Engineer Degree-June 1966
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Second Reader: Ralph Hippenstiel, Department of Electrical and Computer Engineering

With the growth of information dissemination over digital communication networks, much research has been devoted to compressing digital image information for efficient transmission. The ability to adjust the desired resolution of an image as the available bandwidth on the network changes allows the user to control the flow of data according to the resources available. In this thesis we integrate multiresolution image compression methods with image recognition. Features of grayscale and binary images of text characters and aircraft line drawings are described using wavelet transform coefficients, wavelet transform subband energy, and Fourier transform coefficients. Transmission of these features over a digital communication link is simulated, and multiresolution recognition performance in the presence of channel noise is presented.

A PROGRAMMABLE OFFSET DIFFERENTIAL ECL FOUR CHANNEL CLOCK GENERATOR FOR APPLICATIONS IN HIGH RESOLUTION DIGITAL ANTENNAS
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Master of Science in Electrical Engineering-September 1996
Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering
Second Reader: Ronald J. Pieper, Department of Electrical and Computer Engineering

Digital antennas are being developed today that will operate directly at radio frequencies (RF), thus eliminating the need for intermediate and broadband processing. Promising techniques include the use of optical processors integrated

with digital technology to provide the speed and bandwidth necessary for this capability. High resolution optical processors utilize a small parallel array of high-bandwidth interferometers to preprocess the RF signal at the antenna. This work documents the design and construction of a 4-channel programmable offset differential ECL clock generator. The clock generator is used in a symmetrical number system 14-bit digital antenna currently under construction in the Optical Electronics Laboratory at the Naval Postgraduate School. Circuit concepts are detailed along with experimental results of the final design. Results show that the 30 ns wide clock signal generated can be accurately positioned in time to facilitate proper latching of the GaAs comparator arrays. Noise levels within each stage of the clock generator are also quantified. The design is researched, assembled and tested in a wire wrap version.

SIMULINK MODELLING OF A MARINE AUTOPILOT FOR TSSE SHIP DESIGNS

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Master of Science in Electrical Engineering-September 1996
Advisor: R.G. Hutchins, Department of Electrical and Computer Engineering
Second Reader: H. Titus, Department of Electrical and Computer Engineering

This thesis covers the design, simulation and analysis of a SIMULINK system designed to predict the maneuvering characteristics of the Total Ship System Engineering (TSSE) program's first proposed hull design. The system is developed in three degrees of freeom. The ship's hydrodynamic derivatives are predicted in MATLAB code, while the engine is modeled completely in a SIMULINK environment.

To test the system's applicability, an underway replenishment scenario is used to simultaneously test the steering and engine control subsystems.

Two controllers are employed in the system. The first is used to drive the ship in a fashion similar to that of a human conning officer during an underway replenishment. The other is a root locus design used to improve the engine's response.

THE DESIGN OF A PREDICTIVE READ CACHE

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Master of Science in Electrical Engineering-March 1996
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Second Reader: Frederick W. Terman, Department of Electrical and Computer Engineering

The objective of this research has been the creation of a hardware design for a Predictive Read Cache (PRC). The PRC is a developmental cache intended to replace second-level caches common in modern microprocessor systems. The PRC has the potential of being faster and cheaper than current second-level caches and is distinctive in its ability to predict data addresses to be referenced by a central processing unit.

Previous research has analyzed the behavior that the PRC must exhibit. During the described research, the behavior was modeled in the Verilog hardware description language. Verilog-XL was used for simulation, which uses the Verilog behavioral model as input. The behavioral model suggests that the internal structure of the PRC could be divided into six modules, each performing part of the function of the whole PRC. Each of these blocks was studied for hardware equivalents, easing the development of the total structural model.

Using Verilog structural models as input, Epoch was used to automatically perform a very large-scale integrated (VLSI) circuit layout and to generate timing information. The Epoch output files are used for further simulation with Verilog-XL to identify critical parts of the design. The result of this research is a complete hardware design for the PRC.

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

RECENT ADVANCES IN THE TECHNOLOGY OF MICROWAVE DEVICES EMPLOYED IN RADAR SYSTEMS, AND THE IMPACT OF THESE TECHNOLOGIES ON POTENTIAL IMPROVEMENTS TO RADAR SYSTEM PERFORMANCE

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Second Reader: Sherif Michael, Department of Electrical and Computer Engineering

This thesis is a study of the recent advances in microwave device technology that can be applied to the improvement of phased array radar systems which are able to provide multifunction capabilities to navy ships. The study was undertaken to provide guidance to military planners who are often required to keep abreast of developments in a rapidly changing field of technology. The fact that even the most advanced presently-used radar systems in the navy are based on five to ten year-old technology verifies the need for this study.

Microwave Power Modules which combine vacuum tube and Solid State technology have been developed and have demonstrated advanced performance characteristics. Their advantages, such as very wide bandwidth and ability to operated at much higher ambient temperatures than those of the Solid State devices have opened up new opportunities for their use in Radar systems. However, output power capability of MPM, while growing rapidly, is still below the minimum level required for a phased array radar on board a midsize ship operating in confined waters.

The present technology available however in Solid State Transmit/Receive modules, does supply the capabilities needed for a realization of all active phased array radar. Such a system will enhance ships operational capabilities while achieving a reduction of the prime power consumption as well as in needed space. The applicability and characteristics of these devices are presented in this thesis.

CONTROLLER DESIGN, ANALYSIS, AND PROTOTYPE FOR SHIP SERVICE CONVERTER MODULE

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Second Reader: John G. Ciezki, Department of Electrical and Computer Engineering

The Navy has invested in an effort to update the ship electrical distribution system for new vessels. The new architecture divides the ship into specific zones containing common energy conversion devices. Rather than the traditional AC distribution, DC will be produced at the source (a multiphase alternator connected to a controlled rectifier). An integral part of the proposed DC distribution system is the Ship Service Converter Module (SSCM) which acts as a buffer between a main DC bus and a specific zone in the ship. Currently a research effort is underway to make available two Reduced Scale Advanced Development (RSAD) 100kW SSCMs for testing at the Naval Surface Warfare Center, Annapolis. The Power Laboratory at the Naval Postgraduate School is responsible for delivering two identical prototype controllers based on digital signal processors for the RSAD SSCMs. The focus of this thesis is the design, construction and testing of the prototype controllers. This engineering effort includes the following: the analysis of the performance of various control algorithms through simulation; the refinement of the selected algorithm; the design, assembly, and testing of the controller and its supporting hardware; the development and testing of the software; and the integration and testing of the complete system.

ENHANCED VISUALIZATION METHODS FOR CHANNEL EFFECTS IN THE RADIO FREQUENCY MISSION PLANNER

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Master of Science in Electrical Engineering-December 1995
Advisor: Gus K. Lott, Department of Electrical and Computer Engineering

This thesis presents the design of visualization enhancements for the Radio Frequency Mission Planner. The RFMP uses radio frequency propagation models to predict and analyze electromagnetic behavior within a terrestrial environment described by a system operator. The core of RFMP is a set of six propagation models employing different modeling methods and producing output with varying degrees of accuracy. Enhancements to RFMP visualization require the display of the stochastic characteristics of model output. Detailed study of the PROPHET and TIREM propagation models within RFMP, along with the RFMP system architecture, produced visualization enhancements capable of displaying model stochastic behavior regardless of errors or distribution type. Proposed improvements build upon LOTT PLOT calculations and standard model output to extend system visualization power by measuring confidence in computed field values. These enhancements aide the user in identifying planning shortfalls and accelerating plan revisions.

IMPROVEMENTS IN THE THREAT SIMULATOR MODEL DEVELOPMENT ENVIRONMENT

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Second Reader: Frederic H. Levien, Department of Electrical and Computer Engineering

Currently there are a limited number of tools available for quantifying the effectiveness of a shipboard anti-shipping missile electronic attack waveform. The *P-3 Captive-Carry Correlation* algorithms, which include the *Threat Simulator Model Environment* and the necessary preprocessing for open-loop field tests, represent a unique approach to numerically evaluating electronic attack effectiveness. This thesis addresses modifications to the *Threat Simulator Model Environment*, tuned using hardware-in-loop threat simulator (closed-loop) data obtained from the Central Targeting Simulator anechoic chamber. The *Threat Simulator Model Environment* plays a significant role in calculating a miss distance from P-3 captive-carry open-loop field test results. The closed-loop results originally used to tune the model were taken with a sampling rate of 1 Hz and provided encouraging results. This thesis documents several modifications to the *Threat Simulator Model Development Environment* and the incorporation of closed-loop (Central Targeting Simulator Facility) results generated using a 50 Hz sampling rate. The modifications and the use of higher bandwidth data (50 Hz) significantly improves the correlation between the model results and the threat simulator performance in the anechoic chamber.

PERFORMANCE ANALYSIS OF MILSTAR LOW DATA RATE DOWNLINK

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Second Reader: Paul H. Moose, Department of Electrical and Computer Engineering

In this thesis a model of the Milstar communication satellite downlink is developed for two modulation techniques and an error analysis is performed for both. The first signaling technique investigated is M-ary frequency-shift keying (MFSK) where the system is evaluated for a partial-band jamming environment. An analysis with worst case partial-band noise jamming is performed and performance as a function of the energy per bit-to-jammer power spectral density ratio is plotted for Milstar's various MFSK modes. Also considered is the signal power-to-jammer power ratio for

the various modes. The second signaling technique investigated is differential phase-shift keying (DPSK). A similar error analysis is performed for the DPSK signal, and the performance as a function of the energy per bit-to-jammer power spectral density ratio and signal power-to-jammer ratio are plotted. For both modulation formats, all plots are obtained for a constant bit error rate of 10^{-5} and for four different thermal noise levels. Technical descriptions of the capabilities and functions of the Milstar satellite system including signal processing, frequency plan, and waveform design are also included.

ANALYSIS OF HARDWARE IMPLEMENTATION AND SPEED CONTROL OF A SLIP ENERGY RECOVERY SYSTEM

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Master of Science in Electrical Engineering-December 1995
Advisor: John G. Ciezki, Department of Electrical and Computer Engineering

This thesis involves the construction and testing of a Slip Energy Recovery System (SERS). The principal component of the SERS is a wound rotor induction machine which allows for extraction of slip power from the rotor which in turn provides a means of speed control. Induction machines normally operate at a constant speed, but SERS offers a method of speed control which increases efficiency by returning the slip power back to the system.

In this research effort, various tests required to analyze speed range, signal waveforms and power flow were conducted. Additionally, an analog and a microprocessor-based control scheme were implemented for speed control. A number of studies are presented to validate and contrast the proposed circuits.

The system data collected during validation studies are compared against the theoretical operation of the SERS. After construction, alternative topologies are investigated in order to assess the configuration that provides an optimal speed range. A baseline was established and it is shown that the location of the transformer in the SERS has a significant influence on the speed range.

Results from further testing of the baseline configuration revealed that in regards to waveforms and power flow, the system responded as expected.

PERFORMANCE OF FFH/BFSK SYSTEMS WITH CONVOLUTIONAL CODING AND SOFT DECISION VITERBI DECODING OVER RICIAN FADING CHANNELS WITH PARTIAL-BAND NOISE INTERFERENCE

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Second Reader: Ralph Hippenstiel, Department of Electrical and Computer Engineering

An error probability of analysis of a communications link employing convolutional coding with soft decision Viterbi decoding implemented on a fast frequency-hopped, binary frequency-shift keying (FFH/BFSK) spread spectrum system is performed. The signal is transmitted through a Rician fading channel with partial-band noise interference. The receiver structures examined are the conventional receiver with no diversity, the conventional receiver with diversity and the assumption of perfect side information, and the self-normalized combining receiver with diversity. The self-normalized receiver minimizes the effects of hostile partial-band intereference, while diversity alleviates the effects of fading. It is found that with the implementation of soft decision Viterbi decoding that the performance of the self-normalized receiver is improved dramatically for moderate coded bit energy to partial-band noise power spectral density ratio (E_b/N_t). Coding drives the jammer to a full band jamming strategy for worst case performance. Nearly worst case jamming occurs when barrage jamming is employed and there is no diversity even in cases where there is very strong direct signal. Performance improves as the constraint length of the convolutional code is increased. Performance is seen to degrade slightly with increasing diversity except in instances of a very weak direct signal. Also, soft decision decoding is found to be superior to hard decision decoding by approximately 4 dB at moderate E_b/N_t.

PERFORMANCE OF A COMMUNICATIONS SYSTEM WHEN SUBJECTED TO THE PGS 402 ULTRA-WIDE-BAND IMPULSE GENERATOR

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This thesis is an investigation of the performance of a communications system when subjected to the PGS 402 ultra-wide-band (UWB) impulse generator. Also investigated is the shape of the pulse at different points in the receive path of the receiver.

Measurements were taken at an Electromagnetic Interference Test Facility. Bit error rate measures were taken for a fixed pulse repetition frequency (PRF) of 5 kHz for varying signal power-to-jamming power ratios (S/J) and for fixed S/J with varying PRF. The shape of the pulse was measured both when the pulse was transmitted and when the pulse was directly injected into the receiver, bypassing the antenna. Measurements for both the transmitted pulse and the directly injected pulse were recorded in the time domain at the output of the Impedance Matching Unit, Exciter/Power Amplifier, Voltage Control Oscillator, Tuner/Mixer, and Demodulator.

Lastly, a determination was made of the maximum effective distance of the jammer from the receiver and the effective isotropic radiated power (EIRP) of the jammer required to render the receiver unreliable.

ANALYSIS, SIMULATION AND DESIGN OF THE MAPHAM CONVERTER

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In the mid to late sixties, Dr. Neville Mapham worked extensively as an application engineer in the Semiconductor Products Department of the General Electric Company, where he specialized in inverters and the high-frequency operation of silicon controlled rectifiers. His success in the power electronics field produced three equivalent parallel output resonant converter configurations, the center-tapped supply, the bridge, and the center-tapped load. To further expand on Dr. Mapham's work, this thesis analyzes, simulates, and designs the center-tapped supply and bridge topologies. Simulation of both configurations is conducted utilizing PSpice software. In addition, the center-tapped supply converter is constructed and studied in the Power Systems Laboratory. For design purposes, a specific listing of hardware components is given. Series connection through a transformer of the Mapham bridge is investigated and implementation issues are addressed.

A WIDE ANGLE SPLIT-STEP PARABOLIC EQUATION MODEL FOR PROPAGATION PREDICTIONS OVER TERRAIN

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The problem of radiowave propagation over irregular terrain is solved by using the wide angle parabolic equation method. The terrain is characterized by its height profile and its ground constants (here conductivity σ $\varnothing\times$). We consider horizontal polarization and treat the ground as perfectly conducting (PEC) to simplify the formulation. This thesis uses a piecewise conformal transformation to flatten the irregular terrain. The equations are solved by the split-step Fourier algorithm. A Hanning window is used both in spatial and in wavenumber domains to contain the computational domain. Effect of some numerical parameters such as the horizontal step size, height of computational domain

on the accuracy of the solution is investigated. The numerical results are compared with available results for some typical propagation problems.

DESIGN AND EVALUATION OF AN INTEGRATED, SELF-CONTAINED GPS/INS SHALLOW-WATER AUV NAVIGATION SYSTEM (SANS)
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The main problem addressed by this research is to find an alternative to the use of large and/or expensive equipment required by conventional navigation systems to accurately determine the position of an Autonomous Underwater Vehicle (AUV) during all phases of an underwater search or mapping mission.

The approach taken was to advance an existing integrated navigation system prototype which combines Global Positioning System (GPS), Inertial Measurement Unit (IMU), water speed, and heading information using Kalman filtering techniques. The hardware and software architecture of the prototype system were advanced to a level such that it is completely self-contained in a relatively small, lightweight package capable of on-board processing of sensor data and outputting updated position fixes at a rate of 10 Hz; an improvement from the 5 Hz rate delivered by the prototype. The major changes to the preceding prototype implemented by this research were to install an on-board processor to locally process sensor outputs, and improve upon the analog filter and voltage regulation circuitry.

Preliminary test results indicate the newly designed SANS provides a 100% performance improvement over the previous prototype. It now delivers a 10 Hz update rate, and increased accuracy due to the improved analog filter and the higher sampling rate provided by the processor.

NPS HIGH RESOLUTION SYNTHETIC APERTURE SONAR
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Master of Science in Applied Physics-December 1995
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This thesis investigated the use of synthetic aperture techniques to achieve a long effective aperture, high resolution, imaging sonar. The approach included a full simulation of the system using the MATLAB programming environment that provided a model for developing six data processing algorithms and a working 25KHz, 1 m baseline, air medium synthetic aperture sonar. The six azimuthal processing techniques included: 1) a normal, real aperture, 2) an unfocused synthetic aperture, 3) a hybrid focused-unfocused system, 4) a fully focused one line algorithm, 5) a limited two-dimensional, fully focused algorithm and, 6) a limited two-dimensional, hybrid focused-unfocused algorithm. This thesis compared the run times, resolutions, and signal to noise ratios achieved by the six techniques both in simulation and experimental measurements collected with the actual prototype.

COMPUTER SIMULATION OF AN UNMANNED AERIAL VEHICLE ELECTRIC PROPULSION SYSTEM

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There has been a substantial increase in the use of electric propulsion systems in Unmanned Aerial Vehicles (UAVs). However, this area of engineering has lacked the benefits of a dynamic model that could be used to optimize the design, configurations and flight profiles. The Naval Research Laboratory (NRL) has accurate models for the aerodynamics associated with UAVs. Therefore the proposed electric propulsion model would use the torque and RPM requirements generated by the aerodynamic model and provide an accurate representation of the desired UAV electric propulsion system. This thesis reports on the development of such a model. The model is adaptive in the sense that motor and battery parameters can be altered by the user to reflect systems currently in use or those considered for future systems. Not only will the simulation model accurately reflect the operating conditions of the motor and battery during the mission, but different flight profiles with the same configuration can be evaluated in terms of efficiency based on the Percent Battery Capacity Used (PBCU) at the end of the mission. This Electric Propulsion Simulator is part of a larger NRL project intended to design and deliver UAVs to the Naval Service over the next few years.

ERROR PROBABILITIES OF SPREAD SPECTRUM SYSTEMS IN AN ULTRA WIDEBAND SOURCE (UWBS) INTERFERENCE

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This thesis investigates the potential jamming capabilities of an ultra wideband source (UWBS) jammer on the direct sequence (DS) and frequency hopping (FH) spread spectrum systems using the Advanced Communication Link Analysis and Design (ACOLADE) tool. Error probabilities in both the additive white Gaussian noise channel and the Rayleigh fading channel are obtained with and without convolutional coding. Comparison is made to examine whether an UWBS jamming is more effective on the DS or FH systems given the same jammer power. The thesis also presents how several jammer parameters could be varied in order to inflict more harm on the communication systems.